DSN Mariner Jupiter-Saturn 1977 Prototype Radio Frequency Subsystem Compatibility Status and Test Report

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The DSN Mariner Jupiter-Saturn 1977 prototype Radio Frequency Subsystem compatibility tests were the first hardware and software interface tests conducted between the DSN and the Project. These tests were conducted during May 24-27 1976 using the Compatibility Test Area for the DSN and the Telecommunications Development Laboratory for the prototype subsystem. This report describes these initial compatibility tests and reports the test results.

I. Introduction

The purpose of this report is to provide an assessment and status of telecommunications compatibility between the Radio Frequency Subsystem on the Mariner Jupiter-Saturn spacecraft and the Deep Space Network. This assessment and status is derived from test results obtained between the network, as represented in the Compatibility Test Area, and the subsystem located in the Telemetry Development Laboratory.

II. Test Objectives

The objectives of the tests with the radio frequency subsystem were to:

(1) Verify the capability of the network to receive S-band and X-band signals without degradation of receiver thresholds.

(2) Verify the capability to receive signals from the network without degradation of the subsystem receiver threshold.

(3) Determine the maximum network transmitter static offsets and the maximum-minimum network transmitter sweep rates for reliable subsystem acquisition.

(4) Determine the maximum network transmitter sweep rates for reliable subsystem tracking.

(5) Verify the capability of the network to receive and process uncoded high-rate telemetry without degradation.

(6) Verify the capability of the network to calibrate the subsystem group delays at S- and X-band with zero-delay devices.

III. Test Conditions

The radio frequency subsystem was configured for Receiver 2, Exciter 2, TWT 2, and high-gain antenna for both S- and X-band. A calibrated low-loss coaxial cable S-band link and an elliptical waveguide X-band link of approximately 113 m (370 ft) were used between the Telecommunications Development Laboratory and the Compatibility Test Area.

The ground station software consisted of uncoded telemetry and command processor test software and the planetary ranging assembly operational software.

IV. Test Results

The detailed test results are shown in Table 1 and a definition of terms in Table 2. Significant events and/or other items are noted in the following sections.

A. Radio Frequency Acquisition and Tracking Tests

1. Downlink threshold two-way X-band. The threshold was difficult to measure and was degraded two dB from the one-way measured threshold. This was due to X-band two-way phase jitter, a known problem.

2. X-band two-way residual phase jitter. Residual phase jitter could not be measured due to installation of new minicomputers being carried out at the Compatibility Test Area.

3. Sweep acquisition test. The radio frequency subsystem will acquire at -135 dBm with a rate of -200 Hz/s, but will not acquire at -135 dBm with a positive sweep rate greater than $+100$ Hz/s.

4. Tracking rate test. At high sweep rates (greater than 400 Hz/s), the radio frequency subsystem automatic gain control drops out and causes the transponder to switch to the auxiliary oscillator even though the voltage controlled oscillator remains in lock and continues to track the uplink. It appears to be an automatic gain control detector bandwidth problem.

5. Downlink Radio Frequency Spectrum Test. This test was not performed due to the lack of travelling wave tubes on the spacecraft.

B. Command Tests

No command tests were performed because of unavailability of both network and flight project subsystem equipment.

C. Telemetry Tests

1. Telemetry Processing Verification. This test was performed to the symbol signal-to-noise-ratio verification level using the telemetry command processor assembly. The bit error rate test was not performed due to a lack of hardware/software. This capability was not committed by the network for this subsystem test.

2. Telemetry Performance Test. The X-band Y-factor could not be measured due to low output level from the Block IV Receiver. Performance was verified by calculating received E_b N_o directly from unmodulated receiver power measurement to within $\pm$ 1 dB.

V. Future Activities

Additional compatibility tests will be performed on the proof test model, Flight 1 and Flight 2 spacecraft in the Spacecraft Assembly Facility at JPL during Thermal-Vac testing, and in the Spacecraft Assembly and Encapsulation Facility at the Kennedy Space Center, Cape Canaveral, Florida.

The problem of measurement of the X-band Y-factor at the Compatibility Test Area is in the process of being resolved by a modification. DSN engineering level software for Mariner Jupiter-Saturn will be available to support the prototype spacecraft testing now scheduled for the period of 11 October through 1 November, 1976.

Test software being developed for DSN telemetry tests requires a 2047-bit PN code sequence for bit error rate tests. At the present time, the modulation-demodulation subsystem support equipment does not provide the required code and has no provision for external code input. The possibility of providing either the correct code or an external code input port in the modulation-demodulation subsystem support equipment is being investigated.

VI. Assessment

These radio frequency subsystem tests did not indicate any design interface performance problems between the DSN radio frequency subsystems and those on the spacecraft.

The failure of the radio frequency subsystems to meet the pull-in range and acquisition parameters specified in the design requirements does not constitute an incompatibility with the DSN. These parameters determine the DSN acquisition rates and offsets which are controlled by operating procedures. The out-of-spec condition may be corrected by design change or by specification change with appropriate operational acquisition rate and offset limits.

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Test date	Test title	Deep Space Network						
		RCV	EXC	RNG Mod	CMD Mod	Uplink doppler	Uplink offset	CMA SUBC offset
5-24-76	Downlink threshold 1-way, S-band	BLK III	NA	Off	Off	NA	NA	NA
	Downlink threshold 1-way, X-band	BLK IV	NA	Off	Off	NA	NA	NA
	Downlink threshold 2-way, S-band	BLK III	BLK IV	Off	Off	0	0	NA
	Downlink threshold 2-way, X-band	BLK IV	BLK IV	Off	Off	0	0	NA
	Uplink threshold	NA	BLK IV	Off	Off	0	0	NA
	Receiver acquisition static offset	NA	BLK IV	Off	Off	0	±1200 Hz	NA
	Receiver acquisition	NA	BLK IV	Off	Off	±200 Hz/s	0	NA
	Receiver tracking	NA	BLK IV	Off	Off	100 Hz/s	±72.5 kHz	NA
	Spacecraft transmitter phase jitter, S-band	BLK III 1 & 2	BLK IV	Off	Off	0	0	NA
	Telemetry performance verification, X-band	BLK IV	BLK IV	Off	Off	0	0	NA
	Ranging delay performance	BLK IV	BLK IV	On	Off	0	0	NA
5-27-76	Ranging delay calibration	BLK IV	BLK IV	On	Off	0	0	NA

Table 1. DSN/MJS'77 prototype Radio Frequency Subsystem telecommunications compatibility test

Spacecraft									Test data	
TLM SUBC offset	EXC	RCV	Power	ANT	TWT	RNG	TMU	CDU	Performance	Criteria
NA	2S	2	NA	HGA	2S	Off	NA	NA	−159.5 dBm	−159.5 ± 0.5
NA	2X	2	NA	HGA	2X	Off	NA	NA	−153.0 dBm	−153.0 ± 0.5
NA	2S	2-100 dBm	NA	HGA	2S	Off	NA	NA	−159.5 dBm	−159.5 ± 0.5
NA	2X	2-100 dBm	NA	HGA	2X	Off	NA	NA	−151 (with difficulty)	−153.0 ± 0.5
NA	NA	2	NA	HGA	NA	Off	NA	NA	−151.5	−151.0 ± 0.5
NA	NA	2-130 dBm	NA	HGA	NA	Off	NA	NA	Frequency pushing	Acquisition at ± 2000 Hz
NA	NA	2-135 dBm	NA	HGA	NA	Off	NA	NA	+ 200 Hz/s, No acq −200 Hz/s, acq	Acquisition
NA	NA	2-110 dBm	NA	HGA	NA	Off	NA	NA	DPE = 6 deg	DPE ≤ 10 deg
NA	2S	2	NA	HGA	2S	Off	NA	NA	1.62 deg RMS	2.3 deg RMS
0	2X	2-100 dBm	NA	HGA	2X	Off	TLM SIM	NA	SER = 1.28×10^{-2} SSNR = 3.7 dB	SER = $1.5 \pm .5 \times 10^{-2}$
NA	2S 2X	2-100 dBm	NA	HGA	2S 2X	On	NA	NA	X zero delay S zero delay S range X range DRVID	X zero delay S zero delay S range X range DRVID
NA	2S 2X	2-100 dBm	NA	HGA	2S 2X	On	NA	NA	S = 657.9 ns X = 649.7 ns	<1000 ns <1000 ns

Table 2. Definitions of terms used in Table 1

ANT	Spacecraft antenna
Bit rate	Clock frequency of the telemetry bit information
BLK III exciter	The DSN S-band exciter equipment
BLK III receiver	The DSN S-band receiving equipment
BLK IV exciter	The DSN S-band exciter equipment
BLK IV receiver	The DSN S/X-band receiving equipment
CAR SUP	Downlink carrier suppression due to telemetry modulation
CDU	Command demodulation unit
CMA SUBC offset	Command modulation assembly subcarrier frequency offset relative to nominal
CMD MOD	Command processor assembly command modulation
EXC	Spacecraft S-band exciter equipment
HGA	High-gain antenna
LGA	Low-gain antenna
MGA	Medium-gain antenna
RNG MOD	Planetary ranging assembly modulation
PWR	Spacecraft transmitter power mode
RCV	Spacecraft S-band receiving equipment
RFS	Radio Frequency Subsystem
RNG	Spacecraft ranging channel
SDA SUBC offset	Subcarrier demodulator assembly subcarrier frequency offset relative to nominal
TLM SUBC offset	Subcarrier demodulator assembly frequency offset relative to nominal
TMU	Telemetry modulation unit
TWT	Traveling wave tube amplifier
UNC	Uncoded
Uplink doppler	Ramp rate of the uplink carrier frequency
Uplink offset	Uplink carrier frequency offset relative to the spacecraft receiver rest frequency